Ron de Yong Director

/406.444.3144 • Fax: 406.444.5409 • agr@mt.gov • www.agr.mt.gov



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# Evaluation of the Ascochyta/Mycosphaerella Pathogen in Pulses

Final Report accepted March 2015.

# **Project Summary**

Evaluation of the Ascochyta/Mycospharella Pathogen Complex in Chickpeas, Peas and Lentils for Resistance to Qol and DMI Fungicide

The increase in pulse crop acres over the past decade in the Northern Great Plains and Canada has resulted in an increase in disease pressure. Among the important diseases of pulse crops is the Ascochyta/Mycosphaerella complex, commonly known as Ascochyta blight. Under favorable disease development conditions, the use of foliar fungicides is relied upon to control these fungi. Resistance to the QoI fungicides (azoxystrobin, pyraclostrobin) was reported in Ascochyta rabiei within 3 years of the first use, and rendered the fungicide useless for the control of Ascochyta blight on chickpea. A shift in sensitivity of A. rabiei to the DMI fungicide prothioconazole also has been reported, but this does not appear to be affecting fungicide efficacy in the field at this time. In this research project, methods were developed and isolates from Montana, North Dakota, and Washington were evaluated for sensitivity to QoI and DMI fungicides. In addition, two SDHI fungicides were added due to observed field failures in 2013. Monitoring fungicide sensitivity is crucial in effective disease management. If isolates with resistance are detected at low frequencies, implementing new resistance management strategies may delay, or prevent, the development of a fully resistant population. If high frequencies of resistant isolates are identified, use of the fungicide should be discontinued due to lack of efficacy and economic return.

This project has built on previous work by validating published methodology and developing new methodology where needed for A. rabiei, A. lentis and M. pinodes to screen all fungal species for Qol fungicides (Headline, pyraclostrobin) and DMI fungicides (Proline, prothioconazole). In addition, similar methodology has been used to screen for resistance to two SDHI fungicides, Xemium (fluxapyroxad) and Endura (boscalid).

# **Project Approach**

# 1. Activities performed, by objective:

Objective 1. Collect isolates of Ascochyta/Mycosphearella spp. from chickpea, lentil, and pea in Montana, North Dakota and elsewhere. Baseline isolates from WA, ND, and MT were collected. This has been accepted for publication as 'Lonergan, E., J. Pasche, L. Skoglund, M. Burrows. 2014. Sensitivity of Ascochyta species infecting pea, lentil, and chickpea to boscalid, fluxapyroxad, and prothioconazole. Plant Disease (accepted).' A draft is included with this report.

Objective 2. Develop methods to monitor A. lentis, M. pinodes and A. rabiei isolates for resistance to QoI and DMI fungicides.

Objective 3. Screen isolates of M. pinodes for resistance to QoI and DMI fungicides using previously developed methods.

# Objective 4. Screen isolates of A. rabiei for resistance to DMI fungicides using previously developed methods.

To address the three objectives above, researchers at Montana State University (MSU) validated published methodology and developed new methodology where needed for A. rabiei, A. lentis and M. pinodes to screen all fungal species for QoI fungicides (Headline, pyraclostrobin) and DMI fungicides (Proline, prothioconazole). In addition, they used similar methodology to screen for resistance to two SDHI fungicides, Xemium (fluxapyroxad) and Endura (boscalid). This work was completed after observing field failures of the fungicide Priaxor (Headline + Xemium) in chickpea in 2013. The work has been accepted by the journal Plant Disease for publication. Montana State University researchers also collected 145 isolates from the 2013 pulse crop for 2014 planting (126 from pea, 9 from lentil, and 10 from chickpea). Of those isolates, four chickpea and one pea isolate were insensitive (resistant) to the QoI fungicide Headline (avg inhibition 40.4 - 49.9%); one chickpea isolate was insensitive to Xemium (avg. inhibition 38.3%), and one chickpea isolate was insensitive to Boscalid (avg. inhibition 39.7%). One chickpea isolate from Hill County was resistant to all three of those fungicides. The growers were notified, and in two cases, disposed of the seed so it was not planted. There were some difficulties using a discriminatory dose for screening Ascochyta isolates for resistance to Proline, and those isolates are being screened with additional discriminatory doses currently. From the 2014 crop year for planting in 2015, 86 isolates have been collected so far and will soon be proceeding to test those isolates.

# Objective 5. Distribute the results of this study to stakeholders including pulse crop growers, industry representatives, and researchers.

Presentations by Burrows:

17 December, 2013. Fungicide resistance in pulse crops. Northern Pulse Growers Association Meeting, Great Falls, MT. 260 attendees.

30 January, 2014. Disease management with fungicides. Montana Agribusiness Association meeting, Great Falls, MT. 75 attendees.

4 June, 2014. Agronomy update, MSU County Extension Agent training. Moccasin, MT. 12 attendees.

24 July, 2014. Plant diseases in cereals and pulse crops. EARC field day, Sidney, MT. 100 attendees.

Montana Ag Live: 8 appearances in grant period, 10,000/appearance; estimate talked about Ascochyta blight and fungicides at 50-75% of appearances.

# **Extension publications:**

Agalerts: 3/19/14: Seed treatments for pulse crops; 7/18/14 Ascochyta blight identified in chickpea in northern Montana.

# **Peer-reviewed publications:**

Lonergan, E., J. Pasche, L. Skoglund, M. Burrows. 2014. Sensitivity of Ascochyta species infecting pea, lentil, and chickpea to boscalid, fluxapyroxad, and prothioconazole. Plant Disease (accepted).' A draft is included with this report.

Extension education about fungicide resistance in pulse crops will be ongoing beyond the grant period.

### Impacts:

Based on samples coming through the lab, we identified widespread resistance to Headline fungicide in Ascochyta blight of chickpea (40% of isolates tested) and at low levels (1%) in dry pea.

In 2013, the second year a dual mode of action fungicide (Headline + Xemium, marketed as 'Priaxor') was available in chickpea, we found resistance to both components, Headline and Xemium, in samples from northern Montana. Advice to that grower to rotate fungicides after observing field failures resulted in a gross profit of \$385k. He said 'it could have been worse without your help.' We have since obtained funds from the Montana Specialty Crop Block Grant to confirm resistance and develop molecular markers for rapid identification of fungicide resistance.

Samples of chickpea resistant to the widely used fungicide Headline from Hill and Valley counties in 2013 were not planted in the 2014 crop year, reducing the spread of fungicide-resistant Ascochyta blight.

# 2. The goals of this project were directly applicable to specialty crops.

3. **Partners:** Drs. Julie Pasche and Michael Wunsch from NDSU and Dr. Frank Dugan, WSU, provided valuable advice and conversation regarding this project as well as fungal isolates to develop the baseline for fungicide resistance measurements. They also provided support for the attainment of a \$150,000 grant from APHIS-10201 program for the development of a regional Pulse Crop Diagnostic Laboratory that will offer pathogen detection services for growers and phytosanitary tests for state departments of agriculture. Canadian scientists have expressed interest in the work completed and will use the published methods in their screening efforts.

### **Goals and Outcomes Achieved**

Outcomes exceeded the goals of the project. Methods were developed and fungal isolates were screened for two SDHI fungicides in addition to the QoI and DMI fungicides. See above for details and impact statements.

The target of this project was to reach 500 pulse growers per year. Through the course of the grant, presentations were given directly to 447 stakeholders. A specific listing of these presentations is listed in the project approach section of this report. Additionally, stakeholders have been reached indirectly through 2 extension publication agalerts, each reaching 800 subscribers; a peer reviewed publication (unknown readership); and through 8 Montana Aglive appearances reaching 10,000 viewers per episode.

# **Beneficiaries**

Growers will benefit from this project by not applying fungicide to fungicide resistant fungal populations. Once a rapid detection assay is in place (SCBG funding 2015 proposal 'Detection of fungicide resistant Ascochyta blight') we will offer this as a timely service to growers in making management decisions on their farms. Impacts will be measured by following up with growers on whether that information was used. The detection services will be made available to all pulse-growing states as a result of this service being offered by the regional Pulse Crop Diagnostic Laboratory after the completion of the complementary grant received in 2015.

The beneficiaries of this project are pulse crop growers in Montana and North Dakota. In 2013, the prospective plantings report indicates this will impact 33,000 acres of chickpea, 260,000 acres of lentil, and 745,000 acres of dry pea in MT and ND. They will be impacted by improved management recommendations and early warning of fungicide resistance in Ascochyta blight pathogens. The economic impact will be measured by surveys after the conclusion of this project. In 2010, the pulse industry in Montana was estimated to contribute over \$100 million to the state's economy

The following example illustrates the potential economic impact of this project. In 2013, the second year a dual mode of action fungicide (Headline + Xemium, marketed as 'Priaxor') was available in chickpea, we found resistance to both components, Headline and Xemium, in samples from northern Montana. Advice to that grower to rotate fungicides after observing field failures resulted in a gross profit of \$385,000. He said 'it could have been worse without your help.'

### **Lessons Learned**

This project was timely, had impact on growers in Montana, and will have impacts on pulse crop growers regionally. The education on fungicide resistance delivered by extension personnel will assist pulse and cereal crop growers by helping them make knowledgeable decisions about fungicide use. The final project outcomes exceeded the expectations of the grant by using similar methods but adding two additional fungicides in response to observed field failures in 2013. There were some minor problems with the discriminatory dose for DMIs but those have been worked out and work is proceeding. The results of those experiments are expected within the next 2 months. This information will be used in extension programming in multiple states and Canada.

# **Contact**

Montana State University Mary Burrows 406-994-7766 mburrows@montana.edu

# **Monitoring Pathogens & Health of Montana Honey Bee Colonies**

Final Report accepted December 2015.

# **Project Summary**

Goal of proposed research. The long-term goal of the research is to improve the health of Montana's honey bee population by better understanding the role of pathogens, colony strength, and additional factors in the almond pollination system on colony health. Honey bees are essential pollinators of numerous agricultural crops. Recent increased annual losses of honey bee colonies are associated with pathogens, but the specific pathogen(s) and the host and environmental factors involved remain unknown. We hypothesize that pathogens play a primary role in colony losses. To better understand the role of pathogens in colony losses, we will monitor colony size and pathogen incidence and abundance in select colonies before, during, and after almond pollination. Results from this work are essential to understanding the effects of pathogens on colony health and may lead to the development of strategies that mitigate Montana honey bee colony losses.

# What is the specific issue, problem or need to be addressed by the project?

<u>Problem:</u> Most commercial beekeepers in Montana transport their colonies (~150,000) to California each year for the almond pollination season (February). During this time of year (November to March), beekeepers experience high losses. In fact, during the 2012/2013 almond pollination season, William Dahle a Fairview, Montana---based beekeeper, lost 80% of his colonies; his story was featured in a New York Times article on the plight of bees in the U.S. (see: nytimes.com).

<u>Solution:</u> It is critical to monitor colonies over time in order to understand normal and abnormal pathogen loads and determine the relationship between pathogens and colony health. National level pathogen testing is offered on a time-scale (once per year) that is insufficient to understand the role of pathogens in colony losses. Therefore we monitored colonies before, during, and after almond pollination season to address questions including:

- "What is the normal pathogen level in healthy colonies?"
- "Do bee colonies acquire new pathogens during almond pollination?"
- "Does high pathogen load correlate with colony loss?"

These seemingly basic questions are unanswered and require additional research.

Honey bees are important pollinators of agricultural crops that comprise much of the U.S. diet (valued at \$15 billion annually) and species that augment the biodiversity of both agricultural and native landscapes. Since 2006, the U.S. honey bee pollination force has experienced increased annual losses (averaging 32%), which are partially attributed to Colony Collapse Disorder (CCD). Although previous research indicates that colony losses correlate with elevated pathogen incidence (i.e., viruses, bacteria, fungi, mites), neither the cause of CCD nor the reason(s) for increased colony losses have been identified.

This project did not build on a previously funded SCBG project.

# **Project Approach**

Activities Performed, Goals/Targets and Benchmarks Achieved, Progress Toward Goals and Benchmarks:

- This project has increased the interactions between researchers in the Flenniken Lab at Montana State University with Montana commercial beekeepers by:
  - o obtaining samples from three Montanabased beekeeping operations,
  - o engaging in phone and email exchanges (~ 60-100 exchanges), and
  - by presenting our findings at stakeholder meetings.
- In Year 1, Dr. Michelle Flenniken, and Laura Brutscher, a graduate student in the **Flenniken** lab gave three presentations at the following stakeholder meetings:
  - the Montana State Beekeepers Association meetings (Butte, MT, October 2013 ~60 participants; Lewistown, MT October 2014 ~70 participants); and
  - the Western Apiculture Society meeting (Missoula, MT September 2014 ~200 participants).
  - o In October 2015, Flenniken presented the final report to 75 attendees at the Montana State Beekeepers Association.
- In Year 1 (2013-2014), we obtained ~176 samples of honey bees from Montana-based honey bee colonies that pollinated the almond crop. We met the Year 1 benchmark for obtaining and storing samples.
- In Year 2, 2014-2015 we obtained ~ 105 samples; we experienced problems obtaining samples from 2 of the 3 beekeeping operations. However, we exceeded our goal to obtain 200 samples for pathogen screening; we obtained 281 samples.
- We assessed the pathogen prevalence in 176 samples from the 2013-2014 sample cohort, and 75 samples in the 2014-2015 sample cohort. We tested for over 12 pathogen (viruses, microsporidia, bacteria) in each sample by performing over 3,000 pathogen-specific PCR reactions. We completed our goal to assess the incidence of pathogens associated with honey bee samples obtained from colonies of differing health.
- We completed our **assessment of the abundance** of select pathogens in Year 1 samples, and met our goal to assess pathogen abundance in a subset of our samples (176/281 samples).
- We have determined the incidence and abundance of pathogens in differentially strengthened colonies in our data set and statistically evaluated this data. The complete description and discussion of our results will appear as an "open access" article in the journal Apidologie (website: <a href="http://link.springer.com/journal/13592">http://link.springer.com/journal/13592</a>); .
- The results we have obtained to date indicate that:
  - the most prevalent pathogens in Montana-based commercially managed honey bee colonies were BQCV, LSV2, SBV, Nosema ceranae, and trypanosomatids (i.e., Crithidia mellificae / Lotmaria passim);
  - that pathogen prevalence and abundance were associated with both sampling date and beekeeping operation,

- that prevalence was highest in honey bee samples obtained immediately <u>after almond</u> pollination; samples obtained during almond pollination had the fewest number of <u>pathogens</u>; and
- that weak colonies had a greater mean pathogen prevalence than strong colonies (though the results were not statistically significant, therefore more samples are needed to better understand the relationship between pathogens and colony health).
- o **PI's sent data reports to each beekeeping operation** involved in the study.

No non-specialty crops benefited from this project

Significant project partners included:

- Dr. Katie Daughenbaugh, Senior Research Associate in the Flenniken lab,
- Undergraduate research assistants in the Flenniken Lab
- Montana State Commercial beekeepers five beekeeping operations provided samples for this study

# **Goals and Outcomes Achieved**

- (1) work with Ian Foley, MT Department of Agriculture, enumerate and disseminate important findings to all registered commercial beekeepers in Montana;
  - Target: 60 Montana bee keepers
  - Achieved 75 Montana bee keepers were given a presentation on our results at the 2015
     Montana State Beekeepers Association Meeting, Great Falls, MT, Oct. 16, 2015.
- (2) monitor the number of individuals that attend Dr. Flenniken's presentations throughout the funding period by obtaining attendance information from conference organizers, counting the number of people in attendance, and collecting a list of attendees at each event (e.g., Montana State Beekeepers Annual meeting (~ 100 attendees in 2012), Gallatin Valley Beekeepers Association (~ 60 people), American Federation for Beekeepers Research Conference held in combination with the American Honey Producers Association annual meeting (AHPA ~ 400 members; ~ 200 attendees in 2012), Project Apis m. Honey Bee Health Summit (~150 attendees and broadcast on the internet);
  - Target: Present research at multiple stakeholder events.
  - Accomplishment: To date, results have been presented at the 2015 Montana State
    Beekeepers Association Meeting, Great Falls, MT, Oct. 16, 2015; ~75 Montana Beekeepers.
    Additionally, a presentation is scheduled at the American Federation for Beekeepers
    Research Conference in January 2016, as well as other events in 2016
- (3) Project Apis m. is a national non-profit that supports beekeepers by offering best-management practices and supporting bee research, we plan to distribute appropriate findings via their website (<a href="http://www.projectapism.org/">http://www.projectapism.org/</a>), which reaches numerous individuals that may be measured by the number of views on this site;
  - Target: To have Project Apis m. distribute information based on our findings.

- Accomplishment: Though listed on the website as a "research lab with expertise in honey bee viruses", findings have not yet been distributed on this website. This is because data analysis is still being carried out.
- (4) numerical data on attendances at community events (e.g. 2012 Gallatin Valley Farm Fair ~ 400 students, 2012 MSU Honors Research Symposium ~ 100 students, 2012 NRCS-Bozeman presentation ~ 30 people); and (5) Dr. Flenniken will discuss pathogens that affect honey bee health on MT Ag Live, a popular PBS program.
  - Target: Quantify number of attendees at community presentations.
  - Accomplishmens / List of Community Eventst:
     2015 MSU Honors Research Symposium; 115 students.
    - **2015** National Potato Council Meeting, Invited Speaker, "The Role of Multiple Factors on Honey Bee Health", Kalispell, MT (July 9, 2015); 72 participants.
    - **2015 Morning Star Elementary School,** Honey Bee / Pollinator Health Presentation (including observation colony), Bozeman, MT; over 80 1<sup>st</sup> grade students, 5 elementary level educators).
    - **2015 Gallatin Valley Farm Fair** (over 900 4<sup>th</sup>-5<sup>th</sup> graders attended this event), Belgrade, MT.Honey Bee / Pollinator Health Exhibit Coordinator; Flenniken and four Flenniken lab graduate students gave presentations.
    - **2015 Distinctive Dialogues Host**, topic, "Honey Bee Pollinator Health", Bozeman, MT (April 2015); 15 participants at my table and 65 guests exposed to the topic in general.

# **Beneficiaries**

This project primarily benefited Montana-based commercial and small-scale beekeepers. In addition, beekeepers throughout the U.S., scientists, students, and community members will benefit from the knowledge gained in this study. We worked directly with 5 beekeeping operations, and shared our results with ~ 50 Montana Beekeepers each year at the Montana State Beekeepers Association meeting. There are ~ 60 commercial beekeepers that manage ~150,000 honey bee colonies in Montana (Ian Foley, MTDA).

In 2013 the rental fee was ~\$175 per colony, thus Montana beekeepers collected ~\$26.3 million for pollination services (Project Apis m.). Understanding the factors that contribute to the over 30% annual colony losses could lead to strategies that mitigate these losses and in the long-term will economically impact beekeepers, but an economic impact as a direct result of this study would be difficult to measure. We need to better understand the factors most responsible for honey bee colony losses before the economic impact of our research and recommendations can be measured.

### **Lessons Learned**

The majority of samples were properly handled, shipped, and stored – but there were problems obtaining quality (i.e., well-frozen) samples throughout the study, thus we have modified our

instruction sheets and plan to discuss this in greater detail at upcoming stakeholder meetings so that sample quality can be improved for future studies.

Due to the variable distribution of pathogens in honey bee colonies and between beekeeping operations – our results were not as statistically robust as we anticipated. We can address this in future studies, by increasing our sample size or potentially by obtaining a higher number of samples from fewer beekeeping operations and/or at specific dates (rather than ranges of dates that were best suited for each beekeeping operation in the framework of the before, during, and after almond pollination time-periods).

Overall we had positive interactions with Montana Beekeepers, and can avoid shipping problems in the future by having more clear instructions and by better explaining the need for frozen samples for molecular diagnostics.

### **Contact**

Dr. Michelle Flenniken Montana State University 406-994-7229

Email: michelle.flenniken@gmail.com

# **Cost-Effective Production of Montana Native Plants**

# **Project Summary**

Utilization of native plant material in the intermountain west promotes conservation of valuable resources, reduces energy consumption and promotes human health through reduced herbicide use. Native plants promote native pollinator habitat, ecological stability, disease control and reduced fertilizer use, which lead to reduced consumption and pollution; increases the sustainability of small-scale and large-scale agricultural practices; reduce consumption of non-renewable resources such as gas used to transport natives from bordering states and ultimately promotes the safety and health of both humans and the environment (Peppin et al., 2010, Meyer et al., 2005, FS 2010, NPS).

Due to these reasons a number of surveys have identified a clear market demand for both commercial growers and home landscape consumers for native Montana plants in homeowner and business landscapes (Meyer et al., 2005, Helfand et al., 2006, Larsen and Harlan 2006). In the intermountain west region, where 30% -70% of the yearly municipal water consumption goes towards irrigation of urban landscapes, the demand for native plants is reaching a critical stage for Montana commercial growers and nurseries (Mee et al., 2003, Zadegan et al., 2008, Miller 2011). In the last 30 years, an increased focus in policy encouraging federal land management agencies to use native plant material in large-scale restoration projects has also increased demand for native plant material (Erikson 2008).

The objectives of this project were: 1) to research greenhouse protocols for the production of high-demand yet difficult to propagate native perennial species to meet the demand of Montana commercial growers, and 2) promote information sharing of native plant production, installation, maintenance, and growth protocols among Montana native plant buyers and sellers.

Two "kinks in the pipeline" hinder the meeting of the demand for native plant material. First, rapid production of native plants in a commercially viable setting is limited due to the lack of knowledge of the growth of these plants. In a survey of growers in the Colorado Plateau, the "knowledge of native plant production" was identified by respondents as one of the top most significant limitation to producing native plant material (Peppin et al., 2010). Further research is needed to establish greenhouse production protocols for the cost-effective and successful production of high-demand yet difficult to propagate native perennial plant species.

Secondly, there is a need to increase the communication and collaboration among native plant material suppliers, growers and buyers. According to a survey of 43 growers in the intermountain west region, 92% of the respondents indicated the sharing of information among growers for reliable methods to produce native plant material to be among the top five issues to be addressed (Peppin et al., 2010). For suppliers and buyers, a method to share information on the growth and maintenance of high-demand native perennial plants is vital to the supply and demand of the native plant market. For consumers, knowledge on how to grow, maintain and install native plants is necessary for the utilization and increased demand of Montana native flora.

# **Project Approach**

# **Greenhouse Experiments:**

Arrowleaf balsamroot: A significant positive increase in shoot mass was achieved with increasing fertility applied through manual fertigation at rates of 50, 100, 200, and 400 mg nitrogen/L. A significant negative interaction in shoot mass may occur in a 4-inch square pot at higher fertility of 200 to 400 mg nitrogen/L. The significant negative effect of the 4-inch square pot is shown in a reduced root-to-shoot ratio in the 4-inch square pot. The Cone-tainer appears to better than the 4-inch square pot for propagating arrowleaf in the greenhouse.

Silverleaf Phacelia: Silver-leaf phacelia responded positively to less costly greenhouse production protocols including low application rates of nitrogen, standardized pot configuration (4 inch pots), and a relatively quick greenhouse production schedule of about 32 days to produce flowering plants in typical greenhouse propagation conditions. Silver-leaf phacelia requires limited additional research at this point and is ready for commercial production. Suggested propagation experiments include examination of different media types and vernalization periods to improve out planting success or bloom period.

Mountain Hollyhock: Mountain hollyhock exhibited the greatest growth in 6-inch deep square pots, followed by the 4-inch square pots, and the cone-shaped container. Mountain hollyhock did not respond to fertilizer treatments (0, 50, 100, 200, and 400 mg nitrogen/L), most likely due to the constraints of the pot size. Based on the results of this study, a larger, broader container, such as a 1

gallon pot, should be utilized to propagate mountain hollyhock in the greenhouse. Mountain hollyhock requires limited additional research and is ready for commercial production pending seed germination research.

Wild bergamot: Wild-bergamot growth in container production was not limited by pot size and responded to minimal fertilization without a significant increase in growth beyond 50 mg nitrogen/L. Our results indicate that wild bergamot can be easily produced in the greenhouse with minimal fertilizer inputs and a wide range of container choice. However, wild bergamot is highly susceptible to powdery mildew infection in both the greenhouse and the landscape. Wild bergamot is also highly variable in growth habit when grown from wild-collected seed sources. Recommendations would be to screen local genotypes for resistance to infection and growth habit before commercializing production of this species.

# **Seed Dormancy Experiments:**

Arrowleaf Balsamroot Seed Dormancy: Treatment with Gibberellic Acid (GA), increased germination to greater than 80%, and germination rate was highest with the combination of 750 to 1000 mg/L GA treatment under the influence of harvest date, and after-ripening temperature. This more than doubled previously recorded germination rates. Upon examination of the classification of arrowleaf balsamroot seed dormancy to the specific level and type of physiological dormancy, nondeep physiological dormancy type 2, intermediate physiological dormancy type 2, and deep physiological dormancy types 1 and 3 was indicated, utilizing the Baskin and Baskin classification scheme and are most closely aligned with the class and level, physiological deep dormancy in the Schwienbacher scheme.

Silverleaf Phacelia Seed Dormancy: Silverleaf phacelia displays nondeep physiological dormancy, with dormancy breaking occurring after scarification. When mechanical scarification was provided for at least 90 seconds with new sandpaper, a final germination of  $87\% \pm 5\%$  was achieved in 4 days. The effect of after-ripening (nondeep physiological dormancy type 4) could not be studied as seeds received a pretreatment of 1 year of after-ripening before seed experiments began. Further studies should be completed to test the effect of after-ripening and scarification on newly harvested seeds.

Mountain Hollyhock Seed Dormancy: Results from the study showed that scarification treatments can accelerate and enhance germination while GA treatments by itself are not a satisfactory treatment to break dormancy. Furthermore, the statistical breakdown for GA levels in relation to scarification times showed that GA treatments had good response in Mountain Hollyhock germination speed when applied in seeds that were mechanically scarified. However, low levels of GA (250, 500 and 750 mg/L) are not as good as high levels of GA (1000 mg/L). Finally, the results for excised embryos indicated that mountain hollyhock has a combinational physical and physiological dormancy, characterized as Type 1 dormancy. Further work with mountain hollyhock is required to make seed treatment commercially viable.

Wild Bergamot Seed Dormancy: For wild bergamot, seeds were shown to display little to no dormancy, thus only a few additional experiments were necessary. Wild bergamot seeds collected

from Montana State University's Horticultural Farm, in Bozeman, MT, were shown to germinate successfully with no pretreatment to address seed dormancy. Additional experiments showed that 60 days of cold, moist stratification at 5C exhibited a final germination percentage that was not significantly different from germination without any pretreatment.

### **Native Plant Survey.**

**Research overview:** Research was also completed on all currently operating Montana native plant nurseries involved in herbaceous perennial plant production, propagation, and sales, to assess the status of the Montana native plant market and to identify successes and challenges encountered in the production and sales of native plants in Montana.

A survey approved by the Institutional Review Board (IRB) by Montana State University of 14 questions in a mixed closed and open-ended format was delivered to a total of 30 Montana native plant growers involved in propagating herbaceous native plants that were identified through a list compiled by the Montana Native Plant Society (MNPS 2011).

Due to the small population size, the survey was delivered to the entire population instead of a randomized subset of the population. To ensure an adequate response, the survey was administrated through both interview-based and self-completed modes.

This research resulted in a Native Plant Market Feasibility Analysis & Marketing Recommendations of limited scope that was shared with the growers and several audiences across the intermountain west. It examined the successes and challenges of Montana native plant growers, but failed to capture the wider barriers to the larger retail market.

### **Goals and Outcomes Achieved**

# Goal 1) Greenhouse protocols

**Germination:** A series of six pilot experiments and subsequently six full-fledged experiments were conducted on each of the four species' seeds to determine the classification of seed dormancy type.

Extensive seed dormancy experiments led to classification of seed dormancy type and therefore development of successful germination protocols for three of the four species included in these studies, arrowleaf balsamroot, phacelia, and wild bergamot. In particular, for arrowleaf, this resulted in an increase in germination from 28% to over 80%, greatly increasing the viability of this species for commercial production. Results from arrowleaf and phacelia experiments have been accepted for publication in the grower-accessible Native Plants Journal.

**Greenhouse Production:** A factorial design experiment of 2-3 container types and 5 levels of fertilization were conducted for each of the four chosen native species.

A series of experiments on container preference and fertilizer rate for each of four native species advanced understanding of native plant production and resulted in recommendations for production. For arrowleaf, the discovery of the fast pace root growth with slow shoot growth,

spatial requirements of the caudex, and the sensitivity of the root system to container shape led to specific recommendations for container and fertilizer requirements. This also gave insight into transplanting this species into gardens and plantings. For mountain hollyhock, phacelia and wild bergamot, these series of experiments demonstrated the low-input requirements of the species and their ability to grow under standard commercial greenhouse protocols. Results from the arrowleaf and phacelia experiments are in review for the journal HortTechnology.

Information gained from the germination and greenhouse production experiments was included in brochures we developed for propagation and growth of each species. Brochures were distributed to growers and consumers via professional meetings, with free plant material given to growers, and to interested Master Gardeners helping with the research program.

## Goal 2) Dispersal of information to growers on native plant production

A native plant survey was administered to all native plant producers in Montana with a resulting market and demand report prepared. In total 17 participants (57% response rate) responded to the survey.

Videos describing the steps for seed propagation and plant growth designed and recorded.

Brochures describing the propagation and plant growth methods, as well as the benefits of these four species, were designed and printed. In total 120 brochures were distributed to 3 retail nurseries.

Over 300 native plants were produced in the greenhouse and distributed to retailers and non-profit consumers.

The native plant survey gave us insight into the barriers facing Montana native plant production and areas of research that need further focus. It has shaped additional grant requests from other sources. This information has also been shared in 5 talks over the last year to growers, consumers, and other researchers in order to encourage research in needed areas by growers and other researchers. A breakdown of attendance at the talks is provided below:

Missoula Native Plant Society – 40
Gallatin Valley Garden Club – 30
Montana Ag Experiment Station Horticulture Working Group – 15
Montana Ag Experiment Station Field Day – 10
Chinook County Fair - 3

As results of the experiments were available, videos were made and distributed on Facebook with a current status of 14 likes and 3-5 views per quarter. These videos have also been emailed directly to growers and consumers upon request (currently about 8).

As healthy plants became available from experiments, these plants were distributed to two non-profit native plant restoration projects. Toward the end of the grant period, over 300 arrowleaf,

phacelia, mountain hollyhock, and wild bergamot plants and brochures on growing these plants were delivered to retailers to distribute to their customers as plant to consider in their gardens.

This research resulted in two peer-reviewed publications accepted to the grower-accessible Native Plants Journal, and 1 paper currently in review, 8 videos (2 videos each on 4 plant species researched) on species-specific propagation techniques for nursery growers (available on Facebook), and 4 brochures on species-specific propagation tools & techniques for the general public (handed out at grower and native plant meetings as well as emailed upon request). This research resulted in free native plant material to 3 retail plant nurseries in Montana (along with brochures) to promote use of natives. Additionally, two small non-profit restoration projects received plant material.

### **Beneficiaries**

This project benefited state-wide nursery and native plant growers. Specifically, Montana native plant nurseries and growers collaborated with this project and participated in the Montana native plant survey and market analysis. Montana native plant nurseries and growers have all expressed interest in the results of the species-specific plant propagation brochures, videocasts, and additionally, in the results of the native plant market analysis.

- 17 Montana native plant growers received the results of the survey
- 2 growers received plant materials to distribute to the public
- 2 non-profit restoration projects received plant material, these projects utilized an unknown number of volunteers

#### **Lessons Learned**

While we can conclude that all 4 species have the possibility of commercial greenhouse production, significant challenges still remain for 2 of the species. Arrowleaf plants can be easily grown in the greenhouse to the extent that they produce significant roots but the shoots remain small (their strategy in the wild). Seed dormancy issues with mountain hollyhock still limited the number of plants that we could produce, but production in the greenhouse was amenable to typical greenhouse production practices. Both phacelia and wild bergamot took readily to typical greenhouse and germination practices. Further research on timing of flowering would enhance the salability of these plants and would make them competitive with non-native ornamentals.

For all species, seed production and genetic selection need to become a part of the larger research program on native plants in order to meet the demands of native plant growers. The highly variable plant habit and growth experienced in wild collected seed made some of the species difficult to produce in the greenhouse with some uniformity that the retail market would demand.

This project started with the intent of learning more about the possibility of commercial production of Lewisia rediviva (Bitterroot). However, because seed production is non-existent and wild collecting came up empty-handed in the first year, this species had to be dropped from the program for this grant period. For most native species, in general, this highlights the need for research on

seed production as our native plant survey also showed that the largest barrier to native plant production is seed acquisition and production. While work on greenhouse production should continue, research on seed production needs to come to the forefront.

The Montana Native Plant Market and the Montana Native Plant Market Survey was limited in scope and size to the native plant growers. While the information on native plant specific issues was insightful to addressing the research needs, it did not address the barriers keeping native plants out of the larger retail market. It is our recommendation that a larger native plant market feasibility analysis and survey needs to include all green industry professionals in the state of Montana. This research would result in a more thorough native plant market feasibility analysis and marketing recommendations.

### **Contact**

Tracy Dougher
Division Head for Agricultural Education & Professor of Horticulture
Montana State University
406-994-6772
tracyaod@montana.edu

# Developing a distribution network for Garden Seed Potatoes and Adopting Multiplex PCR for Identification of Potato Pathogens

# **Project Summary**

For this project, we developed a distribution system for Montana Certified seed potatoes to nurseries and garden centers utilizing the Montana County Extension system. In 2011, we submitted a proposal to develop a "Garden Seed" directory for seed potatoes. The purpose of the directory was two-fold. Most importantly, it has served as an avenue to increase the distribution of MT seed potatoes which are grown under very strict tolerances for disease and quality. Garden seed coming in from out of state is often an unknown entity and there is significant potential for bringing in pathogens that may adversely impact our Montana seed potato producers. Second, it has brought new customers to our garden seed producers. We have developed a directory and distributed it to ~800 licensed nurseries in Montana. While the directory has resulted in new customers for the 10 farms that have participated, there are still cost constraints to the distribution of small quantities of garden seed potatoes to individual nurseries and garden centers which are distant to the seed potato growing areas. This spring, we initiated a program through 33 county and 3 tribal extension offices. Individual customers placed orders for seed potatoes through their county extension office. All orders were compiled by the counties and forwarded to the Potato Lab by April 1. We then placed a bulk order with individual seed potato producers and collected the potatoes at MSU. The individual county orders were then packaged by variety and picked up by county agents that were at MSU for a spring training. This program proved to be very popular and we sold >6,500lbs of seed potatoes. This program specifically reached customers that want unique specialty varieties and often purchase them through seed catalogs from out-of-state. While this program was successful, it

was very labor intensive to put all of the orders together. Another problem was that it resulted in competition to retail outlets that sell Montana seed potatoes.

We also developed an online garden seed directory where orders can be placed by nurseries and garden centers. Garden seed potatoes from participating growers were gathered at a centralized location in Gallatin County. Three delivery routes (East, West, North) were established to deliver the potatoes by truck to County Extension offices as drop off/pick-up points where nurseries and garden centers can pick them up. In the South central part of the state, we worked with potato growers there to "back haul" the potatoes from the collection location after they have delivered their individual order to the Gallatin location.

The second objective addresses "pest and disease control". This was accomplished by enhancing our diagnostic methods for potato viruses and making PCR tests more economical through a technique called "multiplexing". Multiplex PCR methods allow for multiple pathogens to be tested for at the same time. Since our programs main function is certification of seed potatoes, any enhancement in diagnostic techniques improves our ability to control diseases and pests by eliminating them from the seed supply through the certification process.

Montana seed potatoes are a \$45-50 million dollar industry which is threatened by the importation of potato pests and diseases. Through this project we significantly increased the planting of Montana seed potatoes throughout the state. PCR is now the industry standard for the detection and identification of plant pathogens. It is imperative that the MSU Potato Lab stays on the leading edge of diagnostic techniques. Adoption of multiplex techniques allows tests to be run simultaneously which reduces costs and improves efficiency.

Both objectives of this proposal dovetailed into previously funded projects. In a 2011 project, we developed a directory to promote Montana Garden Seed potatoes. A 2012 project funded a survey of seed potatoes from out of state for diseases to determine the risk of the out of state seed. The test results indicated very high PVY levels in garden seed purchased from out of state sources. In two cases we detected the ring rot pathogen which has a zero-tolerance and the most feared pest by seed potato growers.

The 2012 funded SCBG also included the purchase of a Real-time PCR instrument. Through that project the MSU Potato Lab optimized a number of assays for individual virus, bacterial and fungal pathogens. Developing multiplex protocols built upon the techniques adopted in the 2012 project.

# **Project Approach**

A website was developed to market wholesale garden seed potatoes and it can be found at <a href="https://www.mtseedpotato.org">www.mtseedpotato.org</a>. This website was used to market garden seed from 2013-2016. Deliveries were performed in March and April of each year primarily to County Extension offices with individual customers picking the seed up there. In 2014 we delivered 11,700#, 20,700# in 2015 and 28,075# in 2016. We covered 27 counties distributed across the entire state. The Montana Potato Improvement Association board of directors is strongly in support of this project because we are increasing the likelihood that home gardeners in their area will plant disease-free seed in their production areas.

The program also promotes Montana Seed potatoes outside of our major growing areas and has been a beneficial education tool for the Montana industry. County Extension agents have been very positive about the program because it brings a clientele into their offices that might not otherwise use their services.

Through this project, the MSU Potato lab adopted protocols for the soft rot bacteria Pectobacterium and a new pathogen, Dickeya. A multiplex assay was adopted which can distinguish different Pectobacterium species. We also refined our use of multiplex-PCR for the identification of different strains of PVY. Prior to this project, we had done a small amount of strain ID using a set of primers developed by Lorenzen, 2006 which can be used to type strains as PVY-O, PVY-N, PVY-NTN, and PVY-NO. In this project we proof-tested a new set of primers developed by Chikh Ali, 2009, which provided additional differentiation of PVY-NO species into two subgroups including PVY-WI. In January of 2015, we evaluated 61 samples for the Post Harvest Test using these primers to identify each isolate to strain. Stewart Grays Lab from Cornell University had duplicates of the same samples and performed the assays independently in their lab. The Gray Lab is responsible for the strain ID's that are performed as part of a national project on PVY. We had excellent agreement between our lab and the Gray lab indicating that we are performing the protocol correctly. The ability to do this in our lab was very timely because Colorado had imposed a minimum tolerance for N-Strains of PVY. That necessitated the testing of PVY-positive lots and identifying them to strain. We were able to fulfil this need through the readiness that was developed through this project. We also used the multi-plexing technique to identify the strains of PVY that were detected in garden seed potatoes purchased from out-of-state sources.

The county extension agents were key to developing the garden seed distribution network. Brent Sarchet, county agent from Lewis and Clark County promoted the network from the beginning and manned a booth for us at the Montana Nursery and Landscape Association in January of 2015. Stewart Gray's lab at Cornell University and Alex Karasev from University of Idaho were valuable resources for refining the PVY strain identification techniques.

### **Goals and Outcomes Achieved**

A garden seed distribution network was created which has greatly increased marketing of Montana seed potatoes throughout the entire state. This reduces the chance of importing damaging diseases and pests that could impact our Montana Seed growers. We are now using multiplex PCR on a routine basis and have been able to employ it to respond to a need of the industry for strain identifications of PVY. We have also adopted a protocol for identification of the soft rot bacteria.

The website and distribution network has been established and will continue to be used by the grower that is taking over the deliveries. Through the work we have performed optimizing the multiplex techniques, additional multiplex techniques will be more readily adopted.

Goal 1. Create website for garden seed directory and placement of orders for seed potatoes COMPLETE

Goal 2. Develop wholesale distribution system for garden seed potatoes through County Extension Offices COMPLETE

Goal 3. Adopt multiplex PCR techniques for identification of potato diseases COMPLETE

Through the development of the garden seed directory in 2011, and building upon that with the garden seed delivery network starting in 2014, we are now distributing nearly 15 ton of seed potatoes for home gardens throughout the state. We are distributing to 27 counties servicing 46 garden centers, nurseries and market farms, 3 schools, and 18+ extension/reservation offices. Through the help of Montana County Extension agents have enhanced gardener's education on why planting disease free potatoes is important for home gardens. We have lab-ready assays for routine identification of PVY strains and for bacterial tuber diseases. This has improved the diagnostic capabilities of the MSU Potato Lab.

Before the garden seed distribution network was developed, we sold 6669# of seed potatoes through a program where MSU County Extension Agents could pick up seed potatoes at MSU. Through the distribution network we have more than quadrupled the amount of seed potatoes distributed throughout the state. We routinely identify 7 different strains of PVY using multiplex PCR and we also have the capability of identifying soft rot bacteria. To date we have not had to use this assay on a routine basis but have it available if needed.

### **Beneficiaries**

All Montana seed potato farms (50 families) benefit from the planting of healthy seed potatoes in surrounding home gardens. 9 of these farms are directly participating in marketing their seed potatoes through the network. Home gardeners throughout the state benefit by having the opportunity to purchase healthy Montana seed potatoes. County Agents and the individual county offices benefit by increasing their clientele base.

Montana seed potato farmers that market seed to states with tolerances for different PVY strains benefit from our lab having the capability of doing the strain identification. All Montana seed potato farms benefit from having a wide array of tests available if a particular problem arises.

# **Lessons Learned**

Never sell a product without getting paid first! It is difficult to collect money on a product that has already been delivered. Websites are very difficult to maintain and the bugs can cause customers to become very disgruntled. We did not proceed with incorporating the identification of Dickeya into our softrot multiplex protocol. That protocol is currently being developed by researchers at Universities in states that currently have outbreaks of that pathogen and specialize in bacterial diagnostics. The protocol they develop will be the standard across the United States and it isn't a good use of our time to work on something that is well-supported elsewhere.

Counties that have cooperated with the distribution network have developed relationships with local businesses and market farms that they otherwise would not have connected with. Some county offices actually have purchased potatoes and sell them directly from their office which increases

traffic. We learned that this is OK in counties where no retail outlets are selling seed potatoes but can cause problems if they compete with local retailers.

### **Contact**

Nina Zidack Director, Montana Seed Potato Certification 223 Plant Growth Center Montana State University Bozeman, MT 59717 406-994-6110

Providing Montana Specialty Crop Producers New Local and Regional Market Opportunities Through Organic Vegetable Seed Production Education, Technical Assistance and Market Development.

# **Project Summary**

There is a growing interest and demand for locally grown, organic seed; yet there is a lack of experienced organic specialty crop seed producers and a lack of education and research to assist specialty crop seed producers in the state. This project provided Montana specialty crop farmers with the skills to produce and improve specialty crop seed varieties on farm; the skills to efficiently trial specialty crop varieties that can be grown for seed as well as processed for a value added return, and assisted specialty crop farmers with diversifying their farm businesses by creating market opportunities for Montana produced specialty crop seeds.

The growing interest in specialty crop production in western Montana in particular has created heightened competition for limited markets. Moreover, specialty crop businesses in Montana's short growing season are looking for opportunities to extend their sales season into the winter months. Specialty crop seed production offers a new enterprise to these market farms as well as opportunities to bring revenue to the farm in the winter season whether through contract growing or marketing seed packets.

This project built upon work previously funded in Washington State that supported the Organic Seed Alliance (OSA) in developing a national market for organic specialty crop seed and in developing an organic seed producer cooperative, Family Farmers Seed Cooperative. The Montana project established a statewide marketing cooperative for Organic Montana grown seed, Triple Divide Organic Seeds Cooperative, and engaged Montana in the Organic Seed Alliance network, including incorporating Montana into the Organic Seed Alliance's strategic plan.

# **Project Approach**

The project delivered the following activities:

- Triple Divide Seeds Cooperative (TDS), a producer owned specialty crop marketing cooperative, was incorporated in 2014. A website, accounting infrastructure (Quickbooks), point of sale seed racks and seed packets were developed. Year 1 sales (2015) were to 8 retail outlets for a total of \$9,541. Year two sales (2016) were to 16 retail outlets for a total of \$18,768. TDS created three seasonal winter positions to clean, pack, and coordinate the sales.
- Two seed production workshops were held at the Montana Organic Association annual conferences in 2013 and 2015. The workshops were attended by 40 specialty crop producers. MSU extension and NRCS personnel attended the workshops. The attendance of the workshops by these agencies led to the development of relationships between the specialty crop seed producers and the support agencies. This development has begun to address one of the barriers presented in the project proposal, the lack of support relationships between TA agencies and specialty crop seed producers in Montana.
- Six specialty crop producers attended the Organic Seed Alliance annual conference held in 2014 and 2016 where they gained valuable seed production education and networked with seed houses. The networking opportunities resulted in five of these seed producers either beginning to produce Organic seed under contract or expanding their production contracts, resulting in approximately \$20,000 in seed contracts.
- Three winter squash varieties were processed at the Mission Mountain Enterprise Center in order to evaluate their potential as both a seed crop and frozen season extended product. The three squash varieties were sold as seed through Triple Divide Seeds Cooperative and two of the varieties were sold as a frozen product through Western Montana Growers Cooperative (WMGC). One of these varieties was grown under contract in 2016 for a national seed house and will be processed into a frozen product to be sold through WMGC.
- A conservative estimate of the economic impact of the project (direct and contractual seed sales) resulted in approximately \$55,000 in new economic activity.

In addition to the project activities and stated results this project solidified Montana producer relationships with the Organic Seed Alliance. This relationship led to the opportunity to host the Northern Organic Vegetable Improvement Collaborative (NOVIC) workshop and field days in September 2016 at Salish Kootenai College in Pablo. The NOVIC project brought organic plant breeders from Cornell, University of Wisconsin, Oregon State University and the Organic Seed Alliance to western Montana. Over 35 people attended the 1.5 day workshop that included field tours at 3 Triple Divide Seeds Cooperative member farms.

The two workshops were held at the Montana Organic Association annual conferences. To ensure specialty crop producers were the direct beneficiaries, the coordinating staff charged a nominal fee for specialty crop farms to cover lunch costs and a separate fee for non-specialty crop organizations and businesses.

The Organic Seed Alliance was a significant partner in the project. They served as a technical assistance contractor for producers as well as an organizer of the seed production workshops. OSA has become a valuable partner in continual Organic specialty crop seed production work in Montana, including managing a specialty crop grant to develop a Quality Management System for Triple Divide Seeds, coordinating field days and advising ongoing production trials, and co-organizing the NOVIC workshop and field days. The Montana Organic Association annual conference provided a host site for delivering two workshops and a network to communicate ongoing information of the project development.

# **Goals and Outcomes Achieved**

Goal	Activities
Goal 1 Improve specialty crop producer profitability through selecting and trialing vegetable seed crops that can be further processed for a value added return.	-3 squash varieties processed at Mission Mountain Food Enterprise Center -3 varieties of seed sold through TDS from the varieties processed -2 varieties sold as value added through Western MT Growers Coop -1 variety identified and currently being grown as a contract for a national seed house and value added product sold through WMGC
Goal 2 Develop specialty crop producers' skills in order to integrate seed production into diversified specialty crop farms for the purpose of building farm financial sustainability.	-2 seed production workshops held with 40 specialty crop producers attending -6 specialty crop producers attended the Organic Seed Alliance conference 2 times -8 producers received ongoing technical assistance from the Organic Seed Alliance -1 face to face technical assistance session with 8 TDS growers
Goal 3 Promote Montana grown, regionally adapted organically produced specialty crop seed.	-Triple Divide Seed Coop incorporated -Website developed -Quickbooks accounting setup -Photographs taken to communicate the TDS grower story to potential buyers -Seed racks designed and built -Seed packet logo and labels developed -Seed packets printed -Retailers contacted and product sold

The development of a quality management system for Triple Divide Seed Coop is a long-term outcome as well as the continual market expansion to retailers and the eventual launching of online sales. TDS is working with the Organic Seed Alliance on its Quality Management System and communicating with retailers on how to better present TDS seeds on the racks to increase sales. Similarly, the social media outreach of TDS is in its infancy. TDS anticipates creating better exposure through this platform in 2017 and beyond. In addition, TDS is working to screen seed varieties to develop a stock seed program that will provide the highest production quality seed to demonstrate to market growers in the region that TDS varieties can be viable options for their enterprises.

Goals	Year 2 Final Target	Actual
Goal 1: Improve specialty crop producer profitability through selecting and trialing vegetable seed crops	5 specialty crop varieties are found suitable for production, processing, and marketability	3 winter squash varieties were evaluated for suitability. Two varieties were found suitable, and 1 variety (Long Pie Pumpkin) is presently being grown for contract seed as well as frozen product sales.
that can be further		, , , , , , , , , , , , , , , , , , , ,

processed for a value		
added return.		
Goal 2: Develop specialty	70 Specialty Crop	40 specialty crop producers received
crop producers' skills in	Producers receive specialty	specialty crop seed production training
order to integrate seed	crop seed production	from the two workshops funded by the
production into	training.	project.
diversified specialty crop		
farms for the purpose of		8 specialty crop farms received ongoing
building farm financial		technical assistance from the Organic Seed
sustainability.		Alliance.
Goal 3: Promote	12 specialty crop producers	In 2016 8 specialty crop producers market
Montana grown,	market MT grown seed	MT grown seed to 16 retail establishments
regionally adapted	under TDS brand; 8 retail	and 1 national wholesale seed house
organically produced	establishments carry TDS	resulting in \$18,768 in sales.
specialty crop seed.	wholesale seed racks	

The project resulted in the incorporation of Montana's only organic specialty crop marketing cooperative. The sales in year 1 were \$9,541 to 8 retailers and in Year 2 were \$18,768 to 16 retailers.

### **Beneficiaries**

Eight farms are direct beneficiaries of the incorporation of the Triple Divide Organic Seeds Cooperative. In the first two years of business total sales have exceeded \$25,000, resulting in approximately a \$1,000 in additional seed sales per farm. Five of the TDS farms have begun or expanded their contractual seed growing, resulting in an additional \$20,000 of potential revenue for these farms. The TDS business has resulted in 3 seasonal positions in the winter to coordinate, pack and manage seed sales; these positions are filled by farmers in the cooperative as well as other farmers in the area seeking additional work. Sixteen retailers carry TDS seeds. With an average mark up of \$1, retail sales capture another \$7500 in revenue. All total, the project conservatively generated \$55,000 in economic activity. In addition to sales and production, 6 farms in two separate years attended a national conference hosted by the Organic Seed Alliance. 40 specialty crop farms attended two workshops on specialty crop seed production funded by this project.

Project beneficiaries include the following:

- 1. 8 member owners of an Organic seed marketing cooperative
- 2. 40 specialty crop farms received 2 days of seed production training
- 3. 16 Montana retailers sell Organic, Montana grown specialty crop seed
- 4. 3 seasonal positions created by the business activities of Triple Divide Seeds

A conservative estimate of \$55,000 in economic activity as a result of the project

### **Lessons Learned**

The project has been a process of developing awareness and understanding of the need for Organic specialty crop seed production as a business diversification opportunity. Originally, the project proposal was for 2 years but, due to the organizing and development nature of the project the project was extended for a third year, which better met the pace of development. This project has

further solidified the need to support farmers over a longer period of time in development work because the availability of farmers for education programs and meetings typically is for a short few months in the winter.

The project has kindled an interest in Organic specialty crop seed production in Montana. In particular, four beginning specialty crop farmers have reached out to Triple Divide Seeds producers since August 2016 to learn about contractual seed growing, both as members of TDS and for other seed houses. These beginning farmers expressed that the market for vegetables, in particular in western Montana, is saturated and they are looking for other enterprises to build their businesses. Three farms certified their operations as Organic in order to join Triple Divide Seeds. All three of these farms also became contract Organic seed growers for various seed houses as a result of the networking opportunities afforded by this project. As previously stated, the project solidified Montana producer relationships with the Organic Seed Alliance. This relationship led to the opportunity to host the Northern Organic Vegetable Improvement Collaborative workshop and field days in September 2016 at Salish Kootenai College in Pablo. The NOVIC project brought organic plant breeders from Cornell, University of Wisconsin, Oregon State University and the Organic Seed Alliance to western Montana. Over 35 people attended the 1.5 day workshop that included field tours at 3 Triple Divide Seed Cooperative member farms.

Organic seed production at the beginning of the project was a relatively new industry for market farmers in Montana. Since the inception of the project there has been a growing awareness of seed production and the potential to incorporate seed into a diversified vegetable business especially as competition for markets has increased. Given that the industry is relatively new and the knowledge of seed production is relatively low for many farms, we believe the outcomes of the project were quite successful especially as noted that in the past month 4 farms contacted TDS growers to learn more about seed production.

The goal 1 appears to be ahead of where Montana growers were presently at when the project began. Goals 2 and 3 built a potential industry and the base knowledge and network to be successful in the industry. Goal 1 is now suitable for those producers to hone in on their businesses and add multiple enterprises to increase the micro-enterprise bottom line. In the future we would have focused on Goals 2 and 3 and waited on Goal 1 until the capacity development was completed in Goal 2 and 3.

# **Additional Info**

None to report

# **Contact Info**

Jan Tusick
MMFEC Director
PO Box 128
Ronan, MT 59864
(406) 676-5901
jan.tusick@lakecountycdc.org

# **Huckleberry Challenges: Pollinator Mysteries, Pests and New Invasive Threats**

# **Project Summary**

Huckleberries are a classic specialty crop with a cultural association with Montana. Huckleberry harvest supports a diverse and economically vulnerable cadre of seasonal workers and a specialized manufacturing segment of small businesses. Fresh huckleberry fruit is a luxury market, with demand driving prices to \$50/gallon or more. However, they are subject to little management, and even less research. A single seminal work (Stark and Baker 1992) on Montana huckleberries provides virtually all of what is known about the biology of this important group of plants. However, it concentrates on habitat, growth and propagation aspects of the plants. Out of 90 pages, only part of a single page mentions insect associates of the plant, and that contains obvious errors. This proposal aimed at correcting this gap in the understanding of this relationship. We studied, for the first time, the pollinators, pests and threats from invasive species of Montana huckleberries.

Huckleberries, like virtually all fruit crops, are insect pollenated. In spite of the fact that the huckleberry flower is a specialized type that normally requires buzz pollination, no one has ever documented the actual bees involved in pollination of the Montana huckleberry. There are over 700 species of bees in Montana. Which pollinate huckleberries? One group that is known to practice buzz pollination are the bumble bees (Bombus spp.), a group experiencing dramatic decline in neighboring regions and establishing their possible role in our area is critical to establishing a base line for equating future pollinator decline. Another buzz pollenating group of bees are members of Andrena. Montana's many Andrena are poorly documented, and their relation to huckleberries is unknown.

Stark and Baker (1992) implicate leaf cutter bees (Megachilidae) in the damage of huckleberry fruit, a behavior never documented for this group. What is actually causing the damage observed? Wasps of the family Vespidae are suspected, but documentation is required. Further, an invasive yellow jacket of this family has been making its way into western Montana in the last few years. What is the impact of that species, if any?

What other insect pests impact huckleberry production? We simply have no data on which to act or advise. The recent introduction of the Spotted-Wing Drosophila (SWD, Drosophila suzukii) into western Montana has drawn interest from Montana's cherry industry, allowing us to state that it is of growing importance in the Flathead. Yet, no notice has been taken of its potential impact on huckleberry in Montana.

We identified, studied and documented the native pollinators involved in huckleberry pollination, surveyed huckleberry stands to establish insect associates of the plants, evaluated those associates for pest status, identified the species responsible for fruit damage and monitored for the penetration of the SWD into the wildlands where the huckleberries grow.

The total lack of information on the insect associates of Montana Huckleberry made this project very important in obtaining base-line data. The ever-increasing danger of newly introduced invasive species and climate change made the project very timely.

# **Project Approach**

Insects associated with huckleberry plants were sampled over two field season, in North West (2014) and South East (2015) Montana. Specimens were prepared, identified and databased. Those associated with pollination and fruit were given particular attention.

Sampling took place from June 5 to August 13, 2014 and from May 10 to August 4, 2015 at 21 sites in northwest and southeast Montana (Figure 1). Twelve sites in the Kootenai National Forest of northwest Montana (Lincoln and Sanders Counties) were sampled during the summer of 2014 and nine sites were sampled during the summer of 2015 in the Custer-Gallatin National Forest of southwest Montana (Madison, Gallatin, and Sweet Grass Counties).

Insects were collected from *V. globulare* plants each field season, beginning as soon as the flowers opened and continuing until the fruit was ripe. Insects sampled from different parts of the plant (i.e. flowers, leaves and stems, and fruit) were kept in separate vials. Insects were individually collected between 0900 and 1600 h using a net, aspirator, or Bioquip® insect vacuum, depending on the type of insect. A beating sheet and sweep net were used to sample less visible insects from the plants' leaves and stems. Bees were placed in a killing jar of ethyl acetate, while other insects were placed in vials of 70% ethyl alcohol. Lepidoptera larvae observed feeding on plants were collected alive, along with *V. globulare* foliage, to be reared in the lab.

All insects were taken to the Montana Entomology Collection (MTEC) at Montana State University (MSU) where they were cleaned, pinned, labeled, given a unique identifier (barcode), and uploaded to the MTEC X:BioD Database managed by The Ohio State University. Diptera specimens were chemically dried with hexamethyldisilizane (HMDS) following the online protocol of the California State Collection of Arthropods (Orozco and Gaimari 2015). Specimens were identified to the lowest taxon possible, using current literature and the help of experts, and sorted into one of three categories: flower associates, leaf and stem associates, and fruit associates. Vouchers are deposited in the MTEC.

Lepidoptera larvae were reared on *V. globulare* leaves collected at the study sites. The leaves and larvae were placed in plastic bags, kept in the lab at room temperature, and checked at least every other day for the emergence of adults. Adults that emerged were pinned, spread, labeled, and identified.

Damaged and undeveloped berries were collected from the plants and brought back to the MTEC for dissection. Berries were kept in closed petri dishes in a walk-in cooler at approximately 4°C until they could be dissected.

All specimen records were uploaded to the MTEC XBio:D database (mtent.org). Data were then extracted from the database into Excel® for analysis. Published natural history data were used in an

attempt to distinguish between true biological associates and incidental visitors. Additionally, species found in low numbers on plants were assumed to be incidental visitors in the absence of some behavior indicating a biological association.

Staff from Kootenai National Forest Data were critical in providing permits, advice and facilities to the 2014 field season. USFWS personnel provided huckleberry data from their ongoing grizzly bear projects to find and use field sites. Specimens and observations were contributed by USGS personnel in Glacier National Park. Gallatin National Forest provided permits for the 2015 field season. Numerous taxonomists assisted with the identification of species, including Dr. David Smith at the Smithsonian, who coauthored a paper on a new species of sawfly.

### **Goals and Outcomes Achieved**

In total, 2,470 arthropod specimens were collected from the V. globulare plants over the two years of sampling. A list of all taxa collected are summarized and discussed in detail in Dolan (2016).

Four hundred fifty-six individual insects were collected from V. globulare flowers (Table 1). Flower visitors included Diptera, Hymenoptera, and Thysanoptera. A total of 2,014 arthropods were collected from the V. globulare leaves/stems and fruits. Two hundred forty of those individuals were determined to have a likely association with the plant (Table 2, Dolan 2016).

A Huckleberry Insects database and webpages have been produced (mtent.org/Projects/huckleberry/huckleberry.html). Data from this project were central to a paper and website on Montana Bumble Bees (mtent.org/Projects/Bees of Montana/bumble\_bees\_home.html).

The Huckleberry website is up, but has still not gone fully "live" with an announcement. To date there has been 810 sessions and 421 unique page views.

The Bumble Bee website has gone live, and the data have been linked to and used by the Montana Natural Heritage program resulting in 4,284 sessions and 2,492 unique page views.

Public Presentations:	<b>Estimated Participants</b>
MSU Plant Sciences Graduate Seminar Series, Spring 2016, Spring 2015	50-60
MSU Extension, Honey Bee Workshop, Spring 2016, Spring 2015	50
Gallatin Valley Farm Fair Bee Booth, Spring 2016, Spring 2015	1,100
Hyalite Elementary School 3-4th Grade, Spring 2016	25
Meadowlark Elementary School, Kindergarten, Fall 2015	25
Petra Academy, Bozeman, 4 <sup>th</sup> Grade, Fall 2015, Fall 2014	20
Shining Mountains Mountaineers, Bozeman (youth group), Fall 2015	20
Missoula Butterfly House and Insectarium, Summer 2015	100
Whitefish, MT Huckleberry Festival, Summer 2015	200
Troy, MT Community Presentation, Summer 2015	100
Bozeman Girl Scout Troop Bug Badge Presentation, Fall 2014	15

The goals to have the collection produced and curated, the website fully populated and released, and peer-reviewed publications submitted by the end of the funding period have all been achieved.

# **Beneficiaries**

Due to a lack of current data, it is difficult to determine the number of individuals benefitting, or the extent of the economic benefit, of this project. The most recent data is from 1996 and indicates that, 59,000 pounds of huckleberries were processed by Montana facilities(Jahrig et al. 1997). Jams, jellies and preserves accounted for 55% of that year's huckleberry product sales of \$1.16 million (Jahrig et al. 1997). However, this is mostly likely a gross underestimate of the huckleberry's economic value because it was based on only 14 of the state's major huckleberry manufacturers (Jahrig et al. 1997) and by 2010, at least 30 Montana companies were known to be making hundreds of local huckleberry products (Skornogoski 2010).

Aside from the commercial pickers and huckleberry manufacturers, there are many individual entrepreneurs picking huckleberries for personal use or to sell to local businesses (Vasquez and Buttolph 2010, ACD personal observation 2014), especially in the Northwest portion of the state. One small cafe owner in Libby, MT estimated that she purchased hundreds of gallons of huckleberries in 2013, mostly from locals who spend their days out picking (ACD personal conversation 2014). Gallon bags of frozen huckleberries sold for \$35-\$45 each during the summer of 2014 (ACD personal observation 2014), but a bag can sell for as much as \$70 at supermarkets in Bozeman (ACD personal observation 2016).

# **Lessons Learned**

The overwhelming importance of bumble bees to the pollination of huckleberry was unexpected, and the difficulty in identification of the several species involved lead to involvement in the Bumble Bees of Montana project, a very important extra outcome unforeseen at the beginning of this project. Discovery of an undescribed species of sawfly that infect huckleberry fruit was also unexpected.

### **Additional Info**

None to report

### **Contact Info**

Dr. Mike Ivie
PO Box 173145
Montana State University
Bozeman, MT 59717
406-994-4610
Mivie@montana.edu

# Test marketing of specialty potato variety MonDak Gold

Final Report accepted December 2015.

# **Project Summary**

The MonDak Gold potato variety has been established as a new multi-purpose pink skinned, yellow flesh potato variety with excellent taste, texture, color, and low acrylamides for French fry processors, industrial food service, restaurant and grocery store chain establishments and alternate market channels for commercialization. Through this project, 2014 crop production of MonDak Gold potatoes was used for this direct market test effort. The project demonstrated the potential of commercial potato production and potato processing in eastern Montana and attracted a potato processor and out-of-state growers to consider the MonDak region.

Marketing efforts were directed to establishing a relationship with fresh pack companies, restaurants, grocery store chains, specialty potato product processing companies and the general public to prove the acceptance MonDak Gold potatoes in all these markets. Establishing a niche market and getting a new crop variety introduced into those markets was timely given the interest of established growers from other states to relocate and grow potatoes in eastern Montana. Additionally, an investor showed interest in locating and building potato processing and fresh pack operations in the MonDak region.

This project built on the previous funded SCBG project's efforts of limited production and test marketing of MonDak Gold potatoes by potato growers Craig Steinbeisser and Oliver Schroeder; and the Enander Potato Seed Farm. Based on positive feedback from several major fresh pack companies, grocery chain outlets, restaurant chefs, commercial growers, and health conscious public, the WADG group was asked to continue market testing for processing, restaurants, grocery chain outlets, organic and local fresh markets to help establish the markets for MonDak Gold potatoes.

Also, a companion proposal was submitted to the North Dakota Specialty Crops Block Grant Program to evaluate other "niche" market potato breeding lines from North Dakota State University and the University of Minnesota at the NDSU Nesson Valley Irrigated Research and Development site near Ray, ND and to produced mini-tubers and Go seed potatoes for future commercial production of MonDak Gold potatoes once markets are established. This companion proposal did not duplicate this project.

# **Project Approach**

- 1. The specialty variety MonDak Gold potato was produced by potato growers in Montana, North Dakota, Minnesota, Texas, and Alaska in 2014. Fifteen organic growers in the Minneapolis area in 2014 also planted small test plots of the MonDak Gold potatoes for assessment and comparisons to the currently grown organic potato varieties.
- 2. The Enander Potato Seed Farm planted generation one certified MonDak Gold potatoes in 2014 for test marketing and to provide planting seed for other potato growers in 2015. Spud Viking

Consultant Chuck Stadick oversaw the MonDak Gold certified seed potato production at the Enander Seed Farm.

- 3. The NDSU Williston Research Extension Center in cooperation with the University of Minnesota planted potato variety trials for the purpose of comparing the MonDak Gold potato variety to currently grown and marketed potato varieties.
- 4. An additional 5 acres of MonDak Gold potatoes were planted at the Nesson Valley Irrigation Site on May 10, 2014 with the production to be used for test marketing during the 2014-2015 marketing season.
- 5. MonDak Gold potatoes grown in 2013 and in 2013-2014 winter potato storage were distributed to end users in the MonDak region during the April-June 2014 period. The MonDak Gold potatoes were delivered to the Fork Peck and Turtle Mountain Tribes in eastern Montana and distributed by Paul Finnicum, Fort Peck Tribal Liaison & Turtle Mountain Tribal Liaison. MonDak Gold potatoes were distributed by Bruce Smith, Dawson County Extension Agent in the Glendive, Montana area. Chet Hill, NDSU Williston Research Extension Center Ag Diversification Specialist distributed MonDak Gold potatoes to area consumers in both eastern Montana and western North Dakota including chefs in local restaurants and local grocery stores. Consumers described the MonDak Gold potatoes as more appealing and more buttery than commercially available potatoes due to the yellow flesh and taste. The diners strongly preferred the MonDak Gold potatoes to the standard Russet Burbank for wedges and mashed potatoes because of their texture and light golden color.
- 6. Approximately 300 people attended the MonDak Ag Showcase event was held July 10-11, 2014 in the Williston, North Dakota area and included field days and tours showcasing the NDSU Nesson Valley Irrigated potato research and demonstration project and the MonDak Gold potato variety plantings.
- 7. The potato variety trials and advanced potato strip trials at the NDSU Nesson Valley Irrigation Research Site were harvested on September 24-25, 2014 by the NDSU Williston Research Extension Center staff in cooperation with the NDSU Potato Breeding and University of Minnesota Breeding staff.
- 8. Consultant Chuck Stadick activities performed included follow up with the following companies: Wendy's Fast Food Chain, OH, McDonalds Fast Food Chain, IL, Lucky Market Foods, CO, Ben Holmes Produce, MN, Michael Foods, MN, Ore-Ida Foods, OR, Richard Barnes Brokerage, AK, Willowcreek Grill, ID, Lefseshack, MT, 4 Rivers Potato, MN, Five Guys Burger and Fries, VA, Cavendish Farms, ND, H.C. Schieding Produce, AR, Ryan Potato, MN, ProHealth Foods, TX, Simplot Company, ID, Terra Gold Farms, WA, The Dish Grill, ID, and Resers, KS.
- 9. Attended the National Potato Council and Expo in Orlando, Florida. There were approximately 1,900 attendees at the National Potato Council events. The WADG team exhibited in a trade show booth to promote the MonDak Gold potato variety for both the fresh pack and potato

processing industries and to promote the eastern Montana and western North Dakota area (MonDak region) for irrigated potato production and processing facilities.

10. The WADG team also participated in the Northern Plains Potato Grower Association (NPPGA) Annual Meeting and Research Reporting Session February 17, 2015 at the Alerus Center, Grand Forks, ND with an estimated 200 attendees. The Williston, ND potato variety test results from the University of Minnesota and the North Dakota State University Potato Breeding Programs were presented and published in the 2015 Research Reports.

This project did not benefit other commodities.

Significant contributors included: Spud Viking Consultant Chuck Stadick helped coordinate the MonDak Gold potato production, storage, and shipment of MonDak Gold potatoes to the test marketers and monitor the test marketing. Dr. Christian Thill, University of Minnesota, and Dr. Susie Thompson, North Dakota State University were in charge of the potato quality tests and monitored and summarized these results from MonDak Gold and the other tested varieties. Bruce Smith, MSU Dawson County Agent, Glendive, MT, and Chet Hill, NDSU Ag Diversification Extension Specialist, Williston, ND assisted in the educational tours, conferences, and workshops and worked with Kathy McLane, Economic Development Director, Glendive, MT and Tom Rolfstad, Williston Regional Economic Development Director, Williston, ND in the promotion of MonDak Gold project activities, marketing efforts and meetings with potential investors.

# **Goals and Outcomes Achieved**

The goals of the project were successfully completed.

A potato variety trial was conducted at the NDSU Nesson Valley Irrigation site near Williston, ND to commercially produce Mondak Gold potatoes for test marketing in the fresh pack and potato process industries.

MonDak Gold potatoes yield potential and quality attributes were established and MonDak Gold potato variety was test marketed by growers, consumers, and fresh pack and process potato companies. MonDak Gold potatoes were established as a potential alternative accepted potato variety for marketing for the fresh pack, restaurant, and process companies.

This project successfully established the yield potential and quality characteristics of the MonDak Gold potato variety as compared to Russet Burbank for the processed food industry and to Yukon Gold in the fresh pack markets. Niche market testing of MonDak Gold in fresh pack, restaurant, grocery store chains, specialty potato product processing and directly with consumers demonstrated its texture, color, and low acrylamides attributes to both the trade and to consumers.

Potato Consultant Chuck Stadick, Caldwell, Idaho worked with restaurant chains, grocery stores, the Ore-Ida group, Cavendish Farms, fresh packs, and grocery store outlets in test marketing to confirm the excellent process qualities of MonDAk Gold potatoes and culinary attributes for French fries, chips, and roasted potato products and fresh pack markets.

Fifteen organic growers in the Minneapolis area in 2014 also planted small test plots of the MonDak Gold potatoes for assessment.

There were approximately 1,900 attendees at the National Potato Council events for our WADG team to showcase the MonDak Gold potato variety displayed at our trade show booth as well as test results showing its attributes of high fry color quality, low acrylamides, and long storage life. Banners were also displayed at our trade show booth on the MonDak region, available irrigated land, and available infrastructure for potato processing facilities.

Granrud's Lefse Shack, Opheim, MT utilized 65,000 pounds of MonDak Gold Potatoes in their lefse products during this reporting period. Granrud's reported that the MonDak Gold potatoes produced an excellent lefse product and is now their preferred red potato variety for lefse making.

# **Beneficiaries**

Our WADG answered many inquiries from growers, processors, ag suppliers, brokers, and potential investors including over 2,500 participants at the National Potato Council, MonDak Ag Showcase, Norther Plains Potato Growers Association meeting, MonDak Ag Spud bowl events, and one on one visitations.

This project demonstrated the potential of the MonDak Gold potato variety to the potato process and fresh pack companies, specialty potato product users and consumers.

### **Lessons Learned**

Getting a new crop variety such as the MonDak Gold variety in to the niche markets in the fast food, fresh pack, and process industry requires investors to locate and build a potato processing plant and/or fresh pack operations in the MonDak region and establish a new potato grower base. Without financial assistance and incentives from Montana and/or North Dakota, the potential investors and out-of-state growers were reluctant to move forward in establishing potato facilities and potato production in the sites considered in the Glendive, MT area.

One unexpected problem was the passing of Dr. Christian Thill, University of Minnesota Potato Breeder and Developer of the MonDak Gold potato variety in August 2014. That was an impediment in the test marketing of the MonDak Gold potatoes, especially in the organic fresh pack markets in Minnesota.

The high cost of potato production and the high costs involved in the introduction of a new potato variety in the market place requires additional years of market testing and product assurance of the new varieties for potential investors and growers to commit to switching from traditional varieties with established markets and established potato growing regions.

# **Additional Information**

None

# **Contact Information**

Name of Applicant: WILLISTON AG DIVERSIFICATION GROUP (WADFo3 D.B.A.)

Contact Name and Title: JERALD BERGMAN, PRESIDENT

Mailing Address: P O Box 1306 City/ZIP: Williston, N.D. 58802

Phone: 701-774-4315 FAX# 701-577-8880 E-mail Address: <a href="mailto:jeraldbergman@ndsu.edu">jeraldbergman@ndsu.edu</a>